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GIFFORD PINCHOT, Forester.

FOREST PLANTING ON THE NORTHERN PRAIRIES.

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FIG. 1. Diagram of forest planting for model farmstead situated in the south-east corner of quarter section 8

FOREST PLANTING ON THE NORTHERN PRAIRIES.

INTRODUCTION.

In no other part of the United States, perhaps, is the need for forest planting greater than on the northern prairies. Protection from wind and storm, and a sufficient supply of posts, poles, repair material, and fuel, are essential for the wellbeing of those who make the prairies their home. Many of the early settlers doubted the possibility of growing trees within the region; others, however, were more confident of success, and through their efforts a variety of trees were planted, under varying conditions. Some of the plantations failed, either through an unfortunate selection of species or through ignorance of the proper way to plant. The larger number, however, were successful.

To determine what species are best adapted for planting on the northern prairies, a study of existing plantations within the region was made by the Forest Service. Only the better groves were selected, since the object of the study was, primarily, to determine the possibilities of a species rather than its average development. The results of the study are given in this circular.

THE NORTHERN PRAIRIES.

LOCATION AND TOPOGRAPHY.

The region called in this report the northern prairies comprises the eastern half of the two Dakotas and the western part of Minnesota. It is generally level, and especially so in the valleys of the middle James and Red rivers. When the topography is broken it is usually by rolling slopes or ridges known as coteaus.

SOIL.

Uniformity of soil over large areas characterizes the region. The most common type is a rich, black loam, which varies in depth from a few inches to several feet. This is underlaid with a yellowish clay, throughout which are scattered calcareous pebbles. Beneath this there may be a layer of blue clay, and then sand and gravel. Usually

there is just enough sand to make the soil absorptive and retentive of moisture, and easily tillable. Near Forestburg, S. Dak., the amount of sand becomes excessive and the result is sand dunes. The other extreme is shown by the stiff gumbo soil of the Red River Valley. As a rule, while clay soils permit tree growth, sandier ones are more favorable to it.

CLIMATE.

The rainfall of the prairies decreases gradually with progress north. At Elk Point, S. Dak., the annual amount is 27.25 inches, while at Grafton, N. Dak., it is but 13.54 inches.

The average annual rainfall for the entire region is approximately 20 inches. In a hilly country this amount would not be enough for tree growth. On the prairies, however, there is practically no run-off, and a small rainfall is sufficient to produce crops.

While a low normal in rainfall may affect the rate of growth and general thriftiness of groves, the extremes of variation affect their actual existence. Table 1 shows the rainfall at Huron, S. Dak., for years which have departed widely from the normal.

TABLE 1.—*Extremes of rainfall.*

Year.	Precipitation April to September.	Precipitation September to April.	Annual precipitation.	Departure from the normal.
	WET.			
	Inches.	*Inches.*	*Inches.*	*Inches.*
1882	21.86	6.26	28.12	[a] +7.71
1885	20.10	5.68	25.78	+5.37
1887	20.18	5.36	25.54	+5.13
1892	19.00	6.19	25.17	+4.76
1896	17.09	9.01	26.10	+5.69
1900	19.03	5.70	24.73	+4.32
	DRY.			
1894	6.34	7.22	13.56	[a] −6.86
1899	9.87	3.79	13.66	−6.75
1903	8.46	5.37	13.83	−6.58

[a] + indicates more than normal, — less than normal.

It will be seen that, in most cases, by far the greatest amount of rain fell during the growing season, June to September. In the three dry years, however, the rainfall during this season was considerably less, and in 1894 was even less than that of the months from September to April. Just such years make it necessary for the planter to select his species with care lest, through the inability of the trees to resist drought, his plantation should fail.

Upon the prairies the winds are almost as constant and regular as they are upon the sea. In the spring they blow from the southeast and bring the rains upon which agriculture largely depends. In the summer the prevailing winds are from the south. These, accompanied by clear skies and continual sunshine, have a wonderful power of drawing moisture from the soil. The effect of this proves serious when these winds are supplanted by the hot winds from the plains. Many a Carolina poplar tree records the occurrence of such winds in a blazelike blight on the southwest side, whence these winds blow. In winter the prevailing winds are from the north and west. The air is then clear, dry, and bracing. Occasionally these winds are very cold, blow with great velocity, and, when accompanied by snow, become the dreaded blizzard.

EARLY PLANTING.

On the unsettled prairies there were no barriers to obstruct the constant winds. Tree planting was early recognized as the best means of accomplishing this. In order to encourage tree planting generally, Congress passed the timber culture act of March 3, 1873. Under this law and its later modifications a good deal of planting was done, both to meet the requirements of the act and to secure the benefit of protection.

In the matter of growing trees some had better success than others. Europeans often used to good advantage the experience they had got abroad. A number of species were introduced; but generally the native trees furnished the most readily available planting material. Cottonwood, boxelder, silver maple, green ash, and white elm are the species that have been most generally tried. Partial successes are rather more common than complete successes. Failures may be attributed in some cases to insufficient preparation of the soil, to wide spacing of the trees, infrequent cultivation, to insects, fire, animals, etc., but mostly to the occasional droughts already referred to. Failures of conifers result from the planting in too small quantity, from the use of too large plants, and from the drying of the roots before planting. Yet, notwithstanding failures, there are many good groves.

In the native trees the discussions of the merits of the species are based upon the general conditions of the region and upon actual measurements of a number of typical planted groves. In the case of introduced trees the data are derived from measurements of groves and from literature on the requirements of these trees. Adaptability and economic usefulness have been the leading considerations in recommending a species for future planting.

Up to the present time groves have seldom been established for direct profit. Owners, however, estimate the value of their groves, on an average, at $1,000 an acre, on the basis that their property would

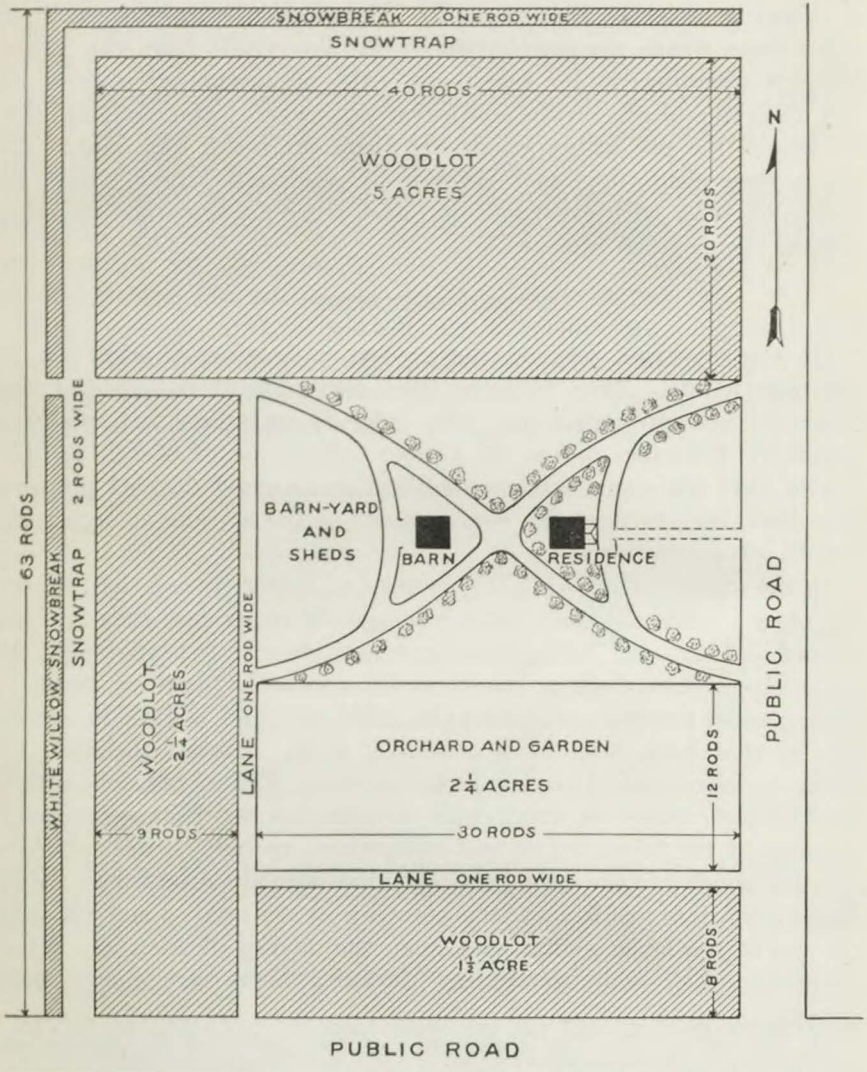

Fig. 1.—Diagram of forest planting for model farmstead situated in southeast corner of quarter section.

be enhanced to that extent if placed on the market. In the purchase and sale of land the grove is really one of the foremost considerations. No one knows the location and character of groves better than the

land agent or the president of the county bank. People pay for the benefit of protection and comfort as they pay for such benefits in a city.

PLANTING FOR PROTECTION TO FARMSTEADS.

In this region protection is required on the south, west, and north sides of buildings. The number and kinds of trees planted largely determine the effectiveness of the windbreak. While many of the protective plantations comprise less than ten acres, this area is not greater than efficiency demands. At the same time the plantation may produce fuel and other material for farm uses.

Since the cold winds are from the north and west, the larger part of the plantation should lie in those directions, and should consist of hardy, rapid-growing evergreens. These afford the best kind of protection when most needed. Deciduous trees are best for the southern part of the plantation. Gaps in the windbreak may seriously affect its protective value, and should always be avoided.

PLANTING FOR COMMERCIAL PURPOSES.

A certain amount of planting may be done for protective and woodlot purposes without regard to its profitableness. When, however, planting for direct profit is contemplated, more extensive inquiries become necessary. No one would plant trees for profit without a reasonable assurance of realizing it. Whether it pays to raise a wood-crop depends upon (1) the market, (2) the cost of producing it, and (3) the species planted.

THE MARKET.

As a result of the absence of natural supplies, posts, poles, and fuel-wood are shipped into this region from northern Minnesota at a freight rate of 10 cents a hundredweight, or about $3.50 a cord. This, with the original selling price and the dealer's profit, brings the local selling price up to from $7 to $11 a cord, depending upon the quality, which is often inferior. In some instances wood is sold by weight. Even at these prices woodland owners do not seek the prairie trade. Cement and iron fence posts have been offered as substitutes for wooden posts, but as yet unsuccessfully. The chances are that all classes of posts, lumber, and fuel will continually increase in price.

COST OF PRODUCTION.

The value of the land is the first and, in some cases, the largest item in the cost of producing a wood crop. Although trees can be grown with profit upon the best soil, they do not require it. Wherever there is soil too rough, too hilly, too sandy, or too wet for agricultural

crops, it should still produce good crops of trees, and for that purpose should be the first selected.

In case willow and cottonwood are used the cost of the planting material should be trifling. Cuttings may often be had for the trouble of gathering them. Unfortunately, coniferous stock is expensive. Planting and cultivating are some of the smaller items of expense.

THE SPECIES PLANTED.

In selecting a tree for commercial planting, its adaptability to the climate and situation, and rapidity of growth are the chief considerations. A tree may be perfectly hardy against cold, like willow and cottonwood, but may not be drought resistant. Hence it must be planted on sites that afford sufficient moisture for its best growth. Another tree may be drought resistant, but may grow too slowly upon dry ground to make it profitable. The time element is always a foremost consideration. If a tree crop is an investment then the sooner it matures the better. The different trees native to this region have usually been divided into two classes: The rapid-growing softwood species, and the more slowly growing hardwood species. The former flourish only in the moist, porous soils of the river valleys, and under such conditions produce a large amount of material in a short time. While the market recognizes a slight difference in price between the two classes of woods, this difference does not seem to equal the difference in the amount of production. Thus an acre of cottonwood might produce 3.5 cords a year, while one of ash would produce 1.5. At $3 a cord the first acre would bring $10.50; at $5 a cord the other would bring $7.50, or a difference of $3 in favor of the fast-growing cottonwood. Quantity rather than high quality is the present demand. Fuel wood need not be durable. The life of nondurable wood can often be lengthened by proper preservative treatment, or by using it in places where the conditions are unfavorable for decay.

TREES RECOMMENDED.

Measurements show that the native species studied do not grow fast enough upon the upland to justify their planting for profit alone; yet two introduced species, European larch and Scotch pine, produce respectively an annual net return per acre of $11.93 and $13.35 and can be planted as a commercial venture. They are both hardy and profitable upon upland and would show even better results when planted in the river valley. The pine can be grown in pure stand, but both can be grown to better advantage when mixed with white spruce.

Cottonwood and white willow are profitable on the deep porous soils of the river valley. Seven cottonwood groves yielded an aver-

age annual net return per acre of $10.67, while eight groves of white willow gave an average annual net return of $24.01.

Of the hardy conifers the following are recommended for protective planting: Scotch pine, white spruce, Norway spruce, western yellow pine, and European larch. Either of the spruces should be mixed with one of the pines or larch.

White elm, green ash, and hackberry are hardy deciduous trees, but grow more slowly and afford poorer protection in winter. Cottonwood and white willow do well even upon the upland if planted in single rows.

In selecting species for park, lawn, and roadside planting, after hardiness, symmetry of form and gracefulness of foliage are the chief considerations. Much depends upon the taste of the individual planter, but the following species seem desirable for all situations and in the order named: Colorado blue spruce, white spruce, bur oak, white elm, green ash, hackberry, and boxelder.

Of the species not recommended—

Black locust is too early and too seriously affected by borers;

Osage orange is not hardy;

Silver maple is not sufficiently drought resistant;

Basswood has not been tried upon the upland, and does not appeal to the tree planter;

Butternut lacks good qualities;

Diamond willow is a bushy shrub and grows slowly;

Black spruce is too slow of growth;

Red cedar grows slowly and suffers from the effects of the cedar apple fungus;

Lombardy, Carolina, Norway, Russian, and balsam poplars are inferior to the common cottonwood.

White pine, jack pine, honey locust, and black cherry are not being planted enough to recommend them on a basis of experience in growing. It is likely, however, that they would grow well if properly planted and cared for.

DISCUSSION OF THE SPECIES.

These notes comprise a more detailed discussion of the merits of each species. They are based upon general observations as well as upon actual measurements of a number of planted groves.

BROADLEAF TREES.

Broadleaf trees as a class require from 6 to 10 times as much water during the growing season as conifers. On bottomlands they grow fast and some of them—cottonwood and white willow—are commercially profitable. On the upland the broadleafed species either fail or grow too slowly to be profitable except for protection.

COTTONWOOD.

Cottonwood is native to the region, where it grows along the streams and lake borders. In favorable situations its growth is very rapid, and often it reaches large size in a comparatively short time. The wood is light, soft, and porous, and decays quickly when exposed. It has been used largely for fuel. Cottonwood lumber is liable to warp and twist, yet of late it has come into use as a substitute for yellow poplar in the manufacture of buggy boxes, and brings a fair price.

The tree has a narrow, open crown, and when grown in pure stands is unable to cast shade sufficient to keep out undesirable undergrowth. In the river-bottom groves, grapevines often dangle from the trees, and tall rank weeds of a jungle-like character cover the ground. In the upland groves a grassy sod is generally present.

Cottonwood has been planted more upon the upland than any other tree. With good cultivation it grows fast for a time, but during an exceptionally dry year it exhibits its unfitness for planting upon the prairie. A notable example of failure exists near Davis, S. Dak. Thirty acres were planted about the year 1872. During the drought of 1894 the trees died by wholesale on the higher ground. At present the grove is used as a pasture, and supports 4 horses and 30 head of cattle from the middle of April to the middle of July or longer. On the other hand a grove planted 25 years ago in the river bottom near Mitchell, S. Dak., will cut 30,784 board feet of lumber to the acre.

Cottonwood may be planted on the upland for a temporary windbreak until a more permanent tree can be grown; or it may be mixed with a more suitable species, to be cut out as soon as it interferes with the others. A few tall trees near the farm buildings may be of service in protecting the buildings from lightning. A single row of trees planted along the roadside will generally produce a large volume of wood in a short time[a] as well as afford protection to neighboring fields.

Whenever a cottonwood grove has thinned out inordinately it should be underplanted with a more permanent tree; at best it is a temporary tree, and should be regarded as such. In the north it is especially liable to become frost cracked; slender trees are often broken during a storm. A leaf rust (*Melampsora populina*) occasionally affects the foliage of small trees and the lower branches of

[a] A single row of cottonwood trees planted 4 feet apart along the public highway has been known to produce 46.9 cords of fuel per mile in 17 years. At $5 per cord this would have a total value of $234.50 or an average annual value of $13.80.

larger trees, but since it makes its appearance late in the season it is seldom serious.

WHITE WILLOW.

White willow has about the same light and moisture requirements as cottonwood, to which it is closely related. It also is a river-bottom tree, but, unlike cottonwood, it is capable of forming and maintaining an exceptionally dense stand. When planted close together the trees put on an exceedingly rapid height growth, and form tall slender stems, well cleared of branches. In natural pruning white willow is perfect. The branches are brittle at the base, and are often shed in such quantity that they accumulate between the rows and may be gathered for kindling.

It makes better fuel than cottonwood. It is easily split, and when well seasoned makes a fence post which will last about six years. For a dense windbreak it is surpassed only by the evergreens. All in all, it is a desirable tree to plant in moist situations, and especially in the sandy, porous soils of the river valleys. It can be planted pure or in mixture with cottonwood. Cuttings are generally used as the planting material for both species.

A single row of willows often brings good results, both for low, dense windbreaks and for fuel and posts. This tree is practically free from frost cracks. The foliage remains green in fall, even after frosts occur, a proof of its hardiness. Caterpillars occasionally defoliate the trees. If they come early in the season and their presence is considered serious a spray may be used. Sheep and hogs devour the leaves and twigs greedily. They keep a forest well cleaned of stump sprouts, and have been used for that purpose. Generally, however, the dense canopy prevents the formation of sprouts.

Because of their rapid growth, both cottonwood and white willow are commercially profitable when planted on bottomland. At an age of 20 years cottonwood averages a height of 72 feet, which means an annual height growth of 3.6 feet. For the same period the white willow has a total height of 50.4 feet, or an average height growth of 2.53 feet a year.

For this age cottonwood groves average 560 trees to the acre, and yield 3.56 cords of wood a year, while white willow has 1,700 trees to the acre averaging 3.42 cords. From this comparison it will be seen that what cottonwood gains in rate of growth in the individual trees is more than compensated for in white willow by the larger number of individuals to the acre. As a lumber tree the former produces an annual net return per acre of $10.57. As a post tree, the latter produces a net return of $24.01.

WHITE ELM.

White elm grows in the river valleys throughout the entire region. It is one of the most abundant and important of the native timber trees. It is also the largest and longest-lived of the hardwood species, and reaches a diameter of 4 feet and an age of approximately 500 years. Under natural conditions its growth is moderately fast and remarkably persistent. Often it has not passed its maximum diameter growth at the age of 170 years.

Upon the upland its growth is somewhat slower, but its hardiness and its longevity seem assured. Its straight trunk and its gracefully spreading and arching crown make it especially desirable as a tree for roadside planting. It produces heavy, hard, strong, and tough wood, which is valuable for special purposes. As a producer of fuelwood it can not, however, rank with some of the faster growing trees.

The light winged seed ripens early in spring, and is soon blown away by the wind. Seedlings can often be collected along the streams. They can be bought cheaply from nurseries.

GREEN ASH.

Green ash is a small tree with a strong taproot and an undivided, straight, and slender stem. Its wood is well suited for wagon tongues, whiffle trees, and other purposes where strength, toughness, and straightness of grain are required, and it is also good for fence posts. It is capable of producing seed at the age of 4 years. Generally large masses of brown seed hang upon the trees after the leaves have dropped. The hardiness of green ash is unquestioned. So far as its requirements for sustaining life are concerned it is one of the least exacting trees. In fact it will live under almost any conditions. Its growth on the upland is, however, too slow to make its planting profitable, and its foliage is too light to make of it a good windbreak. As the tree advances in age, borers generally attack it. Pure plantations of ash are undesirable, and whenever it is planted it should be mixed or underplanted with a heavy-foliaged tree.

BOXELDER.

Boxelder is a small tree with a crooked, branched, or divided stem and a large, full, round crown. By crowding, it is barely possible to produce a fairly straight tree. It has been planted a great deal for windbreaks; but its love for moisture, its low stature, and the small quantity and poor quality of material produced, all unfit it for general planting on the upland. Besides, there are objectionable sprouts from the base, dead branches persist, and borers attack the young

shoots and pith of the branches. The greatest damage, however, seems to be from snow pressure. The drifts generally pile up into the branches on the south side of the windbreak. When they settle, the branches and stems are twisted and broken. This is very common in North Dakota.

Upon the upland its average height growth is 1.36 feet a year, making a total height of 27.1 feet in twenty years. For this period it will produce an average yield of one-half a cord of wood a year, which when sold as fuel wood at $4 a cord is worth an annual net return of 13 cents an acre. These figures on growth and yield alone condemn the tree for all uses except for lawn planting.

SILVER MAPLE.

Under natural conditions silver maple sticks closely to the alluvial soils bordering streams. Where its demands for moisture are satisfied, it grows fast and often forms a large tree. Planted upon the upland its growth is generally much slower. During dry years, groves of this species not infrequently die down from the top. When renewed activity begins, the trees throw out colonies of sprouts below the point to which it died back. These develop equally and produce bushy and undesirable forms.

At best the wood of silver maple is soft and of little value, and its spreading branches are easily split and broken by ice and storms. It has been largely planted as a street and park tree, and should be limited to such a use.

HACKBERRY.

Although hackberry is widely distributed, it does not seem to be abundant in any one place. In this region it is generally not common enough to be recognized by those who happen to see it. It is occasionally found in natural groves, where it associates with elm, ash, and boxelder. In form and habit and in the character of its wood it more nearly resembles elm than any other tree of the region.

On account of the scarcity of the seed, the difficulty in collecting it, and the slowness with which it germinates, the tree has not become popular among planters, and has seldom been used.

BASSWOOD.

What has been said about the distribution of hackberry and the objection to growing young plants of it also applies to basswood. In addition, it is difficult to see how such a soft-wooded, moisture-loving tree could be usefully and successfully grown upon the upland.

BUR OAK.

Bur oak is probably the most drought resistant of the native trees. While other trees stick closely to the stream valley, this tree grows along the bluffs. Occasionally there are groves of it upon the upland.

It is a valuable long-lived tree, but has been neglected by planters on account of an impression that it grows slowly.

CATALPA.

Catalpa is a popular post tree in various parts of the country. In a suitable climate and on favorable situations it is a very profitable tree. Like black walnut, it is hardy only in the southern part of this region, and then only with protection from the north wind. As far north as Turner County, S. Dak., protection becomes absolutely necessary.[a]

BLACK WALNUT.

The good qualities for which black walnut is famous are not developed except in old trees. The species is hardy without protection only in the southern part of this region. With protection it will grow as far north at least as Minnehaha County, S. Dak. Upon the upland its growth is, however, too slow to make its planting profitable. Its shading and protective values are slight.

OTHER BROADLEAF TREES.

Black locust is drought resistant, but it is invariably and seriously affected by borers,[b] even when quite small, and can endure the winters only in the extreme southern part of the region.

Although Lombardy and Russian poplars have been planted quite extensively, they can be replaced by much better trees. Norway and Carolina poplars are very similar. They have the rapid-growth characteristic of the common cottonwood, of which they are considered varieties, and are able, for a time at least, to grow in denser stand than the latter. Both have been tried in different parts of the three States. Hot winds scorch the bark of the exposed trees, and borers are liable to perforate the stems so that young and slender trees are easily broken by the wind. Butternut has no redeeming features.

[a] For a complete discussion of this tree the reader is referred to Forest Service Bulletin No. 37, "The Hardy Catalpa."

[b] For recent information and remedies relating to the locust borer, see Bul. 58, Parts I and III, Bureau of Entomology.

CONIFERS.

In the past, conifers have not been as generally planted as deciduous trees, because they were more expensive, had to be brought from a greater distance, and required greater care in handling. Their admirable qualities for planting upon the prairie are just beginning to be appreciated.

During this investigation 18 different species of evergreens were found growing upon the upland, generally as individual trees, in small groups, or in several rows of larger plantations. Only occasionally do they occur in regular groves.

Evergreens as a class are naturally social. They usually occur in dense, pure stands where they can assist and protect each other in shading the ground and maintaining forest conditions. Wherever they have been planted close enough and in sufficient quantity to create such conditions they have showed themselves to be rather more desirable than most of the broadleaf trees, not only because of their negative qualities—ability to resist drought, heat, cold, storm, and snow pressure—but also on account of their thriftiness and usefulness for protective and commercial purposes.

THEIR COMMERCIAL VALUE.

Of the many trees occurring naturally in a country only a limited number can be considered economic species. To have economic significance a tree must be both useful and profitable. Broadleaf species, as a class, are hard and heavy, and often so scattered that their exploitation is difficult and expensive. On the other hand, conifers generally occur in pure stand over large areas, and are thus cheaply converted into lumber. At the same time they possess a combination of qualities that give them preference with the user of wood. The economic significance of the conifers is reflected in the lumber industry of the United States, 80 per cent of all the sawed timber being derived from this class of trees.[a]

Referring to Prussia, a country in which systematic forestry has been carried on for a long time, and where forest finance has been highly developed in conformity with general economic conditions, Doctor Jentsch[b] states that, in consequence of the economic management of forests, among the numerous indigenous species which formerly existed, only those have been preserved which possess a high value; that 67.5 per cent of the forested area of the country consists of conifers, and that the broadleaf species—oak and beech—are de-

[a] From figures collected by the Forest Service and Bureau of the Census for 1906.

[b] Official catalogue exhibition of the German Empire, Louisiana Purchase Exposition, 1904.

clining in use, while the conifers are increasing. (Scotch pine alone covers a larger area than all the broadleaf species together.)

THEIR PROTECTIVE VALUE.

To be of commercial value a species must possess adaptability, usefulness, and rapidity of growth. These should have foremost consideration even when planting is done mainly for protection, as in the region embraced by this report. Here protective planting is so absolutely essential that groves of deciduous species of little commercial value, which afford shelter only during summer, have been valued at $1,000 an acre. Surely, then, conifers, which are more valuable commercially, and which afford protection during winter when there is most need for it, should be worth a slightly higher price and the extra care necessary in securing a satisfactory stand.

Conifers are sometimes objected to on account of a possible yellowing of the leaves. This is reported as occurring during hard, open winters, with occasional warm, sunny days. On the warm days the leaves become active and transpire water at a time when the frost-bound soil can not supply the loss, hence the drying or "yellowing." This trouble is experienced mostly with trees that have no protection whatever against the sudden changes of heat and cold. Deep-rooted trees like Scotch and western yellow pine, etc., should be planted in preference to shallow-rooted kinds. They should be planted in dense stands, so that they can prevent deep freezing of the soil and protect each other from such midwinter stimulation. While loss from this source is occasionally recorded no evidence of its occurring could be seen during the investigation. Table 2 shows the number of living trees per acre for 4 species and 5 groves.

TABLE 2.—*Number of living conifers per acre in five plantations.*

Species.	Age.	Number of living trees per acre.
	Years.	
Scotch pine	17	2,040
Scotch pine	21	1,513
Austrian pine	22	2,720
White spruce	19	2,740
European larch	21	1,985

So far the main objection to the general planting of conifers has been the excessive cost of the planting material. Experience, however, has proved that coniferous stock can be grown in quantity at a cost which does not make its use prohibitive.

SCOTCH PINE.

Scotch pine is native to the mountains of Europe. It was probably first recognized in Scotland as a tree suitable for cultivation, hence the name "Scotch" pine. It is a large, long-lived tree, reaching a

height of 120 feet and an age of 200 years. It produces a stout taproot, a trunk with smooth, yellow, papery bark and a crown with stout branches and short, light-green foliage. It is remarkable for the rapidity of its growth and for its ability to resist heat, cold, drought, and storm, and to grow in various soils. On account of these qualities its range has been extended under cultivation over the greater part of Europe and parts of Asia. Often it is the leading forest tree. It is especially well adapted to the dry air and abundant sunshine of the plains. Its northern range is given as 70°. The corresponding latitude in North America lies at a distance of 1,642 miles north of the northern boundary of North Dakota. This species has been introduced into the United States, and occasionally a grove is found growing upon the prairie with gratifying success. Its need for light is here supplied, its powers of endurance have been tried by the changing weather, and its rapid growth has been observed and measured. Scotch pine is 33.5 feet high when 20 years old, and has an average yearly height growth for that period of 1.68 feet as against a height growth of 1.36 and 1.39 feet in boxelder and green ash. The maximum annual height growth attained in any one grove of this species was 3.75 feet and occurred between the ages of 7 and 8 years. The trees were as high in two of the groves measured at 15 years as in another grove at 21 years. The difference in growth seems to be accounted for by the difference in character of the subsoil. In the former two it is sandy; in the latter it is loam or clay. The yield for the Scotch pine groves is estimated to be equal to an annual net return of $13.35 upon the upland as against 13 cents in boxelder, $1.71 in green ash, $0.61 in silver maple, and $2.21 in cottonwood.

Table 3 gives a comparison in rate of growth and yield between our available data and those for the same tree grown from the best quality of soil in European forests:

TABLE 3.—*Comparison of height, growth, and yield of Scotch pine in America and Europe.*

HEIGHT.

Age.	American.[a]	European.	Difference.
Years.	*Feet.*	*Feet.*	*Feet.*
5	3.1	3.1	
10	13.3	7.9	5.4
15	24.4	16.2	8.2
20	31.4	25.4	6.0

YIELD.

Years.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
17	2,682		
20		2,349	
			334

[a] Since a single grove is here compared for growth and yield with more general figures taken from "Yield Tables for Pine," by Weise, the table should be taken relatively and as a suggestion rather than in an absolute sense.

Where a tree has a wide range like Scotch pine, different forms of the same tree are liable to develop under different climates, soils, and situations. Scrubby forms of this species are known to exist in certain parts of Europe. Since the seeds have to be imported, care should be taken that they are from the most desirable forms.

EUROPEAN LARCH.

European larch is a tall, straight, and slender tree with a cylindrical stem and a conical, pointed crown of scattered branches and short deciduous foliage. It is a native of the mountains of central Europe, but its range has been greatly extended under cultivation. It produces a strong taproot, and prefers a deep soil, though a moist soil is not necessary. It is one of the most light-demanding trees. When closely planted it soon prunes itself of branches and produces clear timber. Its wood is durable, and of admirable shape for poles, posts, stakes, and railroad ties. In height growth it is rapid and persistent. The height growth on the upland averages 1.80 feet per year for a period of twenty years. It produces an annual net return per acre of $11.93 where planted on the upland.

Although this tree can be grown with profit in pure plantations, like other light-needing trees, the best results can be obtained from mixed planting. Spruce or Scotch pine are well suited for this purpose. In mixture the trees can assist and protect each other and shade the ground completely and continually.

WESTERN YELLOW PINE.

Western yellow pine is the most abundant and most widely distributed tree occurring throughout the Rocky Mountains. It extends eastward into western Texas, north-central Nebraska, and western South Dakota.

Outside of its demands for light it is one of the most inexacting trees, being able to grow in all kinds of climate, soils, and situations. Its drought-resisting qualities are well known.

In the Black Hills it reaches a height of 100 feet and a diameter of 3 feet. It occurs in pure stand over large areas and often constitutes the only commercial tree.

The wood is heavy, hard, and highly resinous, but will soon rot when in contact with the soil. This is especially true of the younger sapwood, and is the greatest objection that can be made to the tree for general planting upon the prairie. This drawback can be largely removed, however, by using a preservative treatment of creosote. In growing plants the seedlings early produce a long taproot. They should be transplanted from the seedbed to the nursery at the end of the first year, and to the permanent site when 3 years old from seed.

WHITE SPRUCE.

White spruce extends as far north on the American continent as any other commercial tree. It is the largest, hardiest, handsomest, and most valuable of the spruces of the North and East. In the region of the Black Hills it frequently reaches a height of 100 feet. It produces a single stem and a full, symmetrical crown, with a dense, bluish-green foliage. The wood is stronger, tougher, and more elastic than pine. It is used for pulp, lumber, posts, poles, and ties.

While the other spruces usually grow in swamps, white spruce more often grows upon drier upland situations. In Manitoba it extends to the border of the treeless plains. On account of its dense foliage, its rapid growth, its hardiness, longevity, and usefulness for protective and commercial purposes, it is regarded as one of the most valuable trees for the prairie.

Being a heavy shader and shade bearer, it can supply a long-felt want as a proper tree to mix with thin-foliaged, light-demanding trees. Groves which are maturing or deteriorating should be promptly underplanted with this valuable tree instead of allowing weeds to grow. When the shorter-lived trees are removed, spruce is there to take their place.

AUSTRIAN PINE.

Austrian pine is native to southern Europe, where, under the most favorable conditions, it reaches a height of 100 feet and a diameter of 3 feet. More generally it does not exceed 75 feet in height. Its wood is light, highly resinous, and durable.

It produces a straight stem, a strong taproot, and a dense crown of stout branches symmetrically arranged. Its foliage is darker, denser, and coarser than that of Scotch pine, and is often crowded toward the ends of the branches.

In Europe it is considered the hardiest and most easily satisfied of forest trees. It is less light demanding than Scotch pine, but its growth is considerably slower, especially so during the early years of its life. Dry air and dry situations are preferred provided the soil is deep and porous. In this region it is frost hardy as far north as Montevideo, Minn. At Grand Rapids, where Scotch and Austrian pines were planted by the Division of Forestry in 1898, all but 5 per cent of the Austrian pines died from extreme cold, while none of the Scotch pines suffered in this way.

OTHER CONIFERS.

Red cedar is also drought resistant, but its growth is slow and its foliage is liable to turn brown and die from the effects of "cedar apple" fungus. Arborvitæ makes a dense, low windbreak, but its growth is exceedingly slow. The same is true of black spruce.

DETAILS OF PLANTING.

Planting should be done in spring as soon as the frost leaves the ground. In this way the trees receive the benefit of the early rains and escape the danger of frost heaving. While the ground may be prepared by agricultural implements, planting must still be done by hand. Each plant should be set deeply and firmly and with as much care as if the success of the whole plantation depended upon it.

PLANTING MATERIAL.

Certain trees, like willows and cottonwood, are cheaply and successfully grown from cuttings. Cuttings should consist of 1 or 2-year-old twigs cut from vigorous trees. They should be of convenient length—about 10 inches—and should be as nearly uniform in age, shape, and size as possible. They can be cut in fall after the leaves have dropped, and kept in well-drained soil till spring, or they can be cut in early spring before growth begins and set out at once.

If the area to be planted is low and wet, and the soil porous, the cuttings can be stuck in without any previous preparation of the ground. On drier sites, the soil should be broken up and pulverized. Vertical holes should be made with a spike or dibble to receive the cuttings. After the cuttings have been inserted, the earth should be firmed down upon them. Not more than 2 inches of the top of a cutting should protrude from the ground. Care should be taken that the buds point upward instead of downward, that is, that the cuttings be planted right end up. If cuttings are taken from seed-bearing trees they produce seed-bearing trees again. If taken from staminate trees the resultant trees will be sterile.

The best results with other species are obtained by planting small trees with roots that are large in proportion to their leaf surface. Nurserymen usually classify trees according to their height in inches. This, however, gives the purchaser no idea of the quality of the stock. Seedlings may be tall and lanky, and have no roots, or they may be short and stout, and have a full, dense root system, according to the way in which they were grown. Wild plants from the forest are not equal to carefully grown nursery stock. At the end of the first year coniferous seedlings can be transplanted from the seedbeds into nursery rows for two years more; or they can be left in the seed-bed for two years and then transferred for another year to the nursery rows. While nearly all conifers grow slowly for the first few years—they may be smaller at three years than some deciduous trees are at one—3-year-old stock is large enough and strong enough to give good results. Older trees are more expensive and less successfully handled. In case of broadleaved species transplants are not always necessary.

SOURCE OF PLANTS.

Where a good deal of planting is contemplated it may be cheapest to raise the planting material in a local nursery.[a] In most cases it will probably be safer to patronize some reliable nurseryman. Orders for plants should be placed early. It should be stated definitely what kind and character of material is wanted, and no substitutes should be accepted. Plants should be shipped by express, and notice of the shipment should be given to the purchaser by telegraph in order that he may promptly take them in charge when they arrive. They should come tied in bundles, and well secured in a strong box, with the roots wrapped in an abundance of moist sphagnum moss. Responsible nurserymen attend to this matter with great care. Failures generally result from the drying out of the plants during shipment. When once killed in this way no amount of subsequent care and labor can save them.

After the trees are received they should be kept cool, moist, and well shaded until planted. If planting can not begin at once, it is desirable to puddle and "heel in" the plants at some suitable place where they can be taken up as needed.[b]

THE NECESSARY OPERATIONS.

PREPARATION OF THE SOIL.

Soil exposed for centuries to the beating of rain and the trampling of animals has become hard and compact. No planting should be attempted without a careful preparation. In new situations the prairie sod should be broken early in the summer and allowed to lie fallow. Late in the fall it should be turned again. This time plowing should be at least a foot deep; the deeper the better, since then the roots can penetrate into the subsoil and become independent of surface moisture. Where the subsoil is clay hardpan, deep plowing is doubly important. Disk harrowing should make the surface soft and fine.

MIXING SPECIES.

The majority of the trees of this region have thin crowns and demand a good deal of sunlight for their growth and development. Foremost among these are cottonwood, green ash, and willow. Spruce, red cedar, and boxelder have denser crowns, and are able to bear a large amount of shade.

If light-demanding trees are set out in pure plantations, they must be so closely spaced that they interfere with each other's growth, or

[a] For details on the establishment of nurseries see Extract 376 from Yearbook of the Department of Agriculture.

[b] For instructions for puddling and heeling in see Forest Service Circular 61.

grasses and weeds come in and rob them of the necessary soil moisture. A pure grove of such trees might require cultivation throughout its entire life. However, since this is impracticable, the best results can be obtained by mixing the light-demanding with the shade-enduring kinds. A proper mixture brings about a more complete use of the soil, and produces a larger quantity and a better quality of material.

A general mixture of a number of different kinds of trees without a knowledge of their requirements must, however, be discouraged. The fewer the number of species mixed the better, provided that one of them is able to shade the ground completely to an advanced age.

The following arrangements of trees in plantations seem desirable:

(a) For upland and bottomland.

No. 1.
(4 feet by 4 feet.)

S S S S
S S S S
S S S S
S S S S

No. 3.
(4 feet by 4 feet.)

Wy W Wy W Wy
W Wy W Wy W
Wy W Wy W Wy
W Wy W Wy W

No. 2.
(4 feet by 4 feet.)

S W S W
W S W S
S W S W
W S W S

No. 4.
(3 feet by 4 feet.)

A A A A A A
A A A A A A
A A A A A A
A A A A A A

No. 5.
(4 feet by 4 feet.)

E W E W
W E W E
E W E W
W E W E

No. 6.
(5 feet by 5 feet.)

C W C W
W C W C
C W C W
W C W C

S = Scotch pine.
W = White spruce.
E = European larch.
Wy = Western yellow pine.
A = Austrian pine.
C = Cottonwood.

(b) For bottomland.

No. 7.
(2 feet by 8 feet.)

W W W W

W W W W

W W W W

W W W W

No. 8.
(4 feet by 6 feet.)

C W C W

W C W C

C W C W

W C W C

No. 9.
(4 feet by 6 feet.)

C C C C C

C C C C C

C C C C C

No. 10.
(4 feet by 4 feet.)

E B E B

B E B E

E B E B

B E B E

W = White willow.
C = Cottonwood.
E = White elm.
B = Black cherry.

SPACING.

In this region wide spacing is undesirable in every respect. It not only necessitates repeated cultivation for a number of years, but it produces a scattered stand of low, branchy trees, with no provision for failures or accidents. On the other hand, trees planted closely and in proper mixtures will soon shade the ground completely and save the expense of cultivation. The formation of objectionable side branches is prevented and the trouble of pruning saved. Planted in this way trees grow more rapidly in height, become shapely, and make a better windbreak in a short time. When some of the trees are overtopped by their neighbors and begin to die they can be cut out and used for fuel.

TREATMENT AFTER PLANTING.

CULTIVATION.

In order to prevent the choking of the young trees by the tall, rank weeds and grasses which spring up soon after exposing the ground, and to conserve the moisture of the soil, the plantation should be

cultivated until the trees are large enough to shade the ground. Cultivation should be shallow and frequent, and the ground should not be ridged up around the trees. The drier the season the more the need for cultivation. It is not advisable, however, to cultivate too late in the summer, since the trees may be inordinately stimulated, and their immature shoots injured by early frosts.

Trees respond very readily to cultivation. This is especially true with such light and moisture-needing trees as cottonwood and green ash. Usually there is a marked decrease in the rate of growth of these trees after cultivation ceases. In groves properly formed, cultivation should not be necessary or possible after a period of from three to five years. The crowns of the trees should then meet and completely shade out all undergrowth.

A mulch of hay, leaves, or manure is sometimes applied to young plantations to secure the same results. Such treatment, however, may stimulate the growth of superficial roots. At best it is but a substitute for cultivation and has no advantage over the latter except that it can be applied at any time of the year, while cultivating must be done during the growing season. In every other respect cultivation is preferable.

Late in fall young plantations of evergreens should be covered with hay or straw from 8 to 12 inches deep. Branches or poles can be used in keeping the straw from blowing off, or, where these are not available, earth can be shoveled here and there upon the straw between the rows. In spring the straw can be taken off. In from three to five years the crowns of the trees should meet.

PRUNING.

Pruning consists in the removal of branches from living trees. It is usually done to secure more shapely trees than could otherwise be had. In groves of proper density this is seldom necessary, as the side branches are shaded out and fall before they reach a large diameter. The degree of natural pruning, however, depends largely upon the kind of tree planted. Light-demanding trees like European larch, cottonwood, black walnut, green ash, and white willow seldom require pruning, while such trees as box elder and silver maple often do.

With evergreens, pruning should be limited to the dead branches. These can be knocked off, but cutting is best. Whenever it is necessary to remove green branches they should be cut off with a sharp knife or hatchet as close to the tree as possible without exposing more of the wood than necessary. If the wounds are large they

should be covered with paint or tar oil to prevent decay. Pruning should be done in winter or early spring.

THINNING.

Thinnings consist in the removal of some of the trees in a grove in order to give the remaining trees more room. The smaller and less-promising trees are usually the ones cut.

In many cases thinnings are necessary, since the trees removed can be used for fuel, posts, stakes, etc., while the remaining trees are benefited by the larger growing space. However, in this region of sunshine, with light-foliaged trees and rather wide spacing, thinnings are of doubtful value, especially since most of the groves are to serve as windbreaks. Farmers in renting their estates usually stipulate in the agreement "that none but dead trees shall be cut."

Occasionally dense willow groves in moist situations have been thinned by their owners with good results. Some of the river-bottom groves furnish all the fuel consumed, as well as other material. Thus the groves become a constant source of revenue in addition to their value as a protection. In general, thinnings are advisable so long as they do not make the growth of weeds and grasses possible. Grass in a grove is always a detriment, and indicates that the leaf cover is not dense enough. Light thinnings which interrupt the leaf canopy only temporarily may be beneficial where a heavy thinning would be positively harmful. Where thinnings are made a good rule is: "Begin early, thin lightly, and repeat frequently."

REGENERATING GROVES.

In woodlots and shelter plantations permanence is especially desirable. Whenever they begin to mature or deteriorate steps should be taken to renew them. The trees planted in this region usually are prolific seeders. All but willow and cottonwood are able to reproduce themselves to some extent under partial shade. Especially is this true of boxelder and green ash. When trees of these species grow close to cottonwood groves their seedlings often come up in dense thickets as an understory. Russian mulberry, hackberry, red cedar, and other species are occasionally introduced into a grove by birds. However, instead of depending upon such chance or volunteer reproduction, or allowing grasses and weeds to grow it is advisable to underplant.

Underplanting is an operation which few have performed in the past treatment of their groves. It is a very practical method of renewing them. Since a good many groves, particularly the older

cottonwood groves, are greatly in need of renewal, it is here especially recommended.

Hardy long-lived species, preferably evergreen, should be planted in regular order among the trees of mature or deteriorating groves. Unless grass and weeds are very rank it will not be necessary to prepare the soil before planting nor to cultivate afterwards. When, however, the young trees of the understory expand and require more growing space, the mature trees of the upper story should gradually be removed.

Approved:

JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *January 25, 1908.*

[Cir. 145]

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